Design and use of a quick stop device for closed study of grinding mechanism

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Abstract

Several drop-tool and quick stop devices have already been developed and used for close study of exact mechanism of chip formation in turning, shaping, planing and drilling. Such devices are used to abruptly freeze the chip in its formation stage. Then the frozen chips are observed under microscopes for precisely investigating the nature and extent of deformation of chips and chip-tool interaction.

The mechanism of material removal and work-tool interactions are very complex in grinding process where large number of randomly spaced abrasives of varying size and shape act together on the work surface. So it is strongly felt to develop and use suitable quick stop device also for grinding for precision study of grinding mechanism. Keeping such needs in view a simple but reasonably effective quick-stop device has been designed and used for microscopic study of frozen transient grinding zone. Some results have been presented in this paper.

Keywords: Grinding, abrasive action, drop tool device

1 Introduction

The exact mechanism of chip formation and chip-tool interaction and their dependence on the various machining parameters essentially happened to be of great interest in the field of machining. The nature and extend of chip-tool interaction in actual machining condition needs quick freezing of the machining action. Several drop-tool and quick-stop devices have been developed and used for close study of chip-tool interactions in turning [1,2], shaping and planing [3,4] and drilling[5]. Such drop-tool and quick-stop devices are designed and used to abruptly stop the machining action and freeze the chips at its formation stage. Then the frozen chip is carefully separated from the workpiece, cleaned, polished and then observed under optical and scanning electron microscope for indepth study of the nature and extent of chip-tool interaction including plastic deformation, built-up-edge formation, adhesion, chip configuration etc. Mechanism of metal removal in grinding is quite complex. In grinding, materials in the form of tiny chips are removed simultaneously by a large number of abrasive grains of randomly varying spacing, size and geometry. Depending upon the mechanical and metallurgical properties of the work material and the type of the grinding wheel, the chips are formed in one or more of the following modes:

- thin long ribbon like chips by shearing-ideal
- leafy chips by ploughing
- blocky chips by fracturing
- much deformed small chips by straining
- spherical chips by overheating

The levels of the grinding parameters; grinding velocity, work-feed and infeed as well as the type and method of application of cutting fluid also significantly influence the chip formation mode and action of the abrasives in grinding.

The tips of the abrasive grains remove material by abrading, ploughing, plastic deformation and grain pull out. For a given work material, the behavior and action of the grits; individual and combinedly, govern grindability which need to be improved, as far as possible but without sacrificing MRR, through reduction of magnitude of grinding forces, specific energy requirement, grinding temperature and wheel-wear.

Ample research and investigation have been carried out [6-12] and are still going on for studying the actual behavior of the abrasive grits during grinding. For the same work-wheel pair, the role of grit is governed by its size, shape and orientation. In addition to that, the concentration of grits also affects grinding action. Recently, the combined action of the grits of a mono layered cBN grinding wheel has been experimentally studied by developing and using [13] a simple quick stop device.

The construction and working method of that quick-stop device have been tried to be improved. The design and working of that simple but effective quick stop device have been presented in this paper. Some typical grinding surfaces obtained and observed by using that device have also been reported here.

2 Design, construction and use of the quick stop device

Many researches conveniently studied the action of single grit in grinding. But it was not that easy to visualize the combined action of a cluster of grits in actual grinding.

The manually operated simple but quite effective quick-stop device designed and developed for freezing grinding action in surface grinding has been shown in fig. 1. Its working principle is schematically shown in Fig. 2. The work specimen in the form of a plate of size, 60×40×60 mm is properly mounted in the device and fixed by screws.

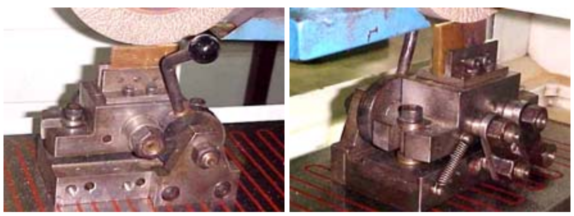


Fig.1: Design and construction of the quick stop device

Before grinding, the specimen was sufficiently raised by lifting the lever which raised the job-holding block with the help of the cam-follower and the two spring loaded parallel strips (Fig.2). On the midway of grinding, the lever is very rapidly pushed down and the work specimen got abruptly disengagement from the rotary wheel under the action of the stiff springs.

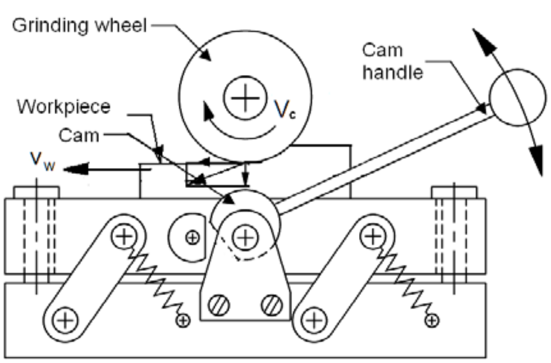


Fig.2: Working principle of quick stop device used in grinding experiment

Four identical work specimens of non-sticky brass were ground by a conventional alumina wheel (Ø200×15, A60K8V) under two different work-speeds, V_W and two different infeeds (d) to also see their effects on the action of the grinding grits. The experiment was carried out via rigid and powerful new surface grinding machine [Alex Machine Tools, Model: NH400] under down grinding mode. The conditions of the experiment undertaken are given in Table-1.

Table-: Conditions of the present experiments

Grinding Machine	: Surface Grinder
Grinding wheel	: Ø200×15, A60K8V
Work specimen	: brass plates, 60×40×6 mm
Process Parameters : grinding velocity, V_g= 63 m/sec work feed, V_w = 5.90, 6.74, and 12.00 m/min infeed or depth, d =20, 30, 60 and 80μm	
Environment	: dry

3 Experimental results and discussion

The ground surfaces with the transient zone obtained by freezing with the help of the quick-stop device are schematically shown in Fig.3.

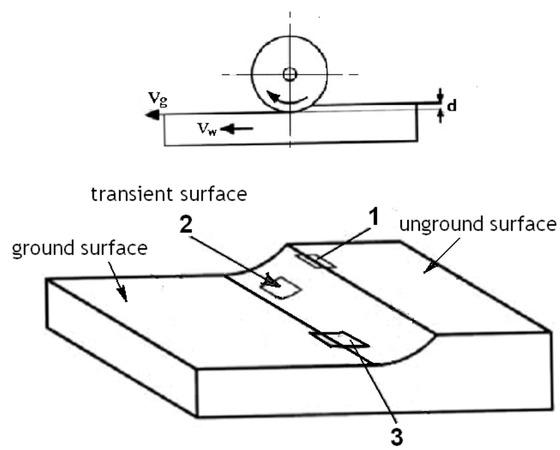


Fig.3: Location of the ground surfaces takes for microscopic study

Behavior and working of a single grit alone has been investigated [14] conveniently and successfully as indicated in Fig.4. But it becomes quite difficult to explore the combined behavior of cluster of abrasives in actual grinding from the appearance of the ground surface.

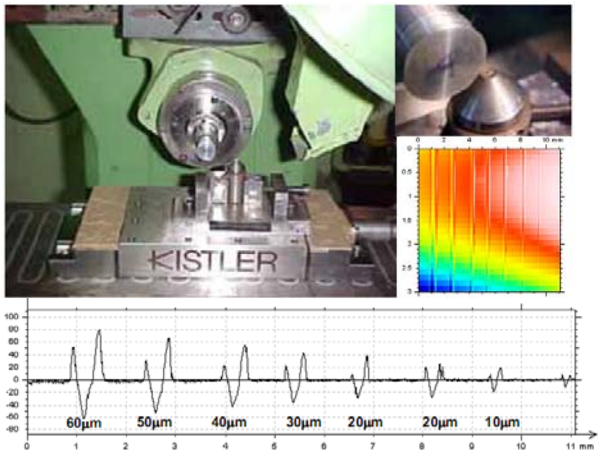
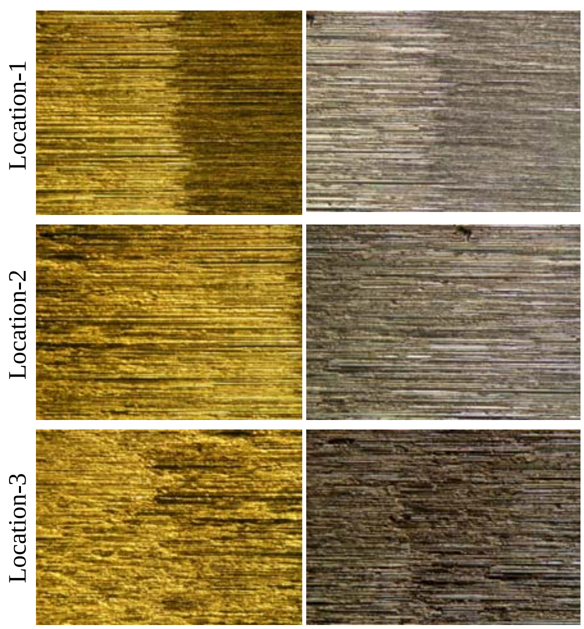


Fig.4: Pattern and sectional profile of the groove formed by the grit in orientation 3.

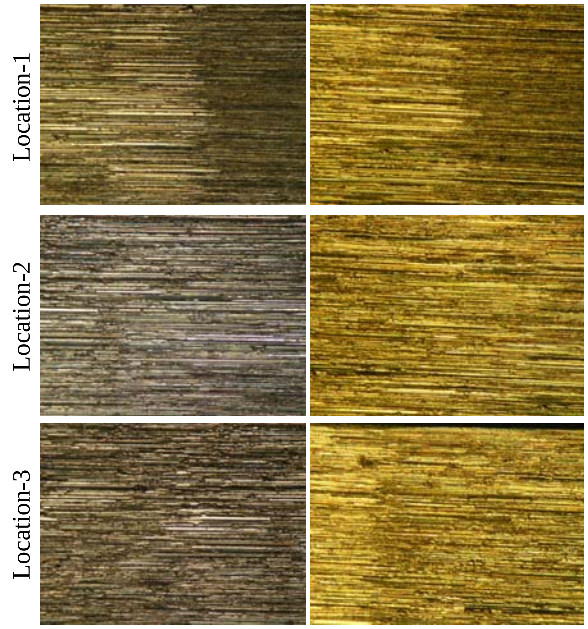
However, attempts have been made to study more closely the mechanism of material removal in conventional grinding using the present quick-stop (grinding) device.

Some of the microscopic views of the ground specimens have been shown in Fig.5, Fig.6, Fig.7, and Fig.8.



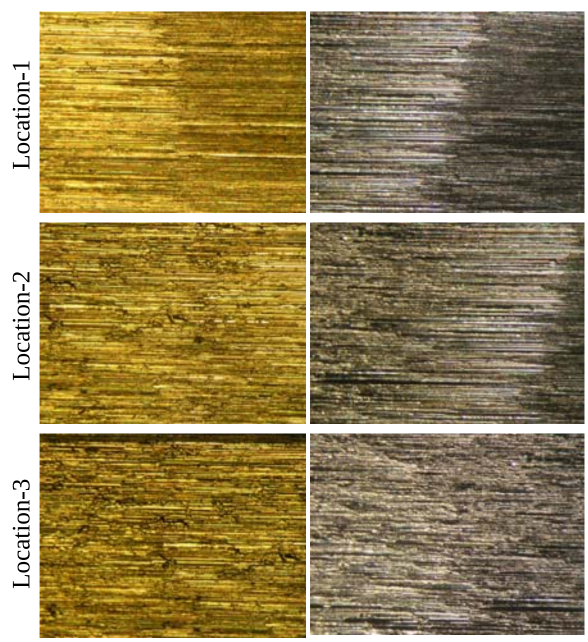
(a) d=20 µm, V_w=6.74 m/min (b) d=30 µm, V_w=6.74 m/min

Fig.5: Micro-views of different zones of after freezing grinding at different infeed and moderate V_w (a) d=20 µm, V_w=6.74 m/min, and (b) d=30 µm, V_w=6.74 m/min



(a) d=60 µm, V_w=6.74 m/min, (b) d=20 µm, V_w=12 m/min

Fig.6: Micro-views of different zones of after freezing grinding at (a) d=60 µm, V_w=6.74 m/min and d=20 µm, V_w=12 m/min



(a) d=30 µm, V_w=12 m/min (b) d=60 µm, V_w=12 m/min

Fig.7: Micro-views of different zones of after freezing grinding at (a) d=30 µm, V_w=12 m/min and d=60 µm, V_w=12 m/min

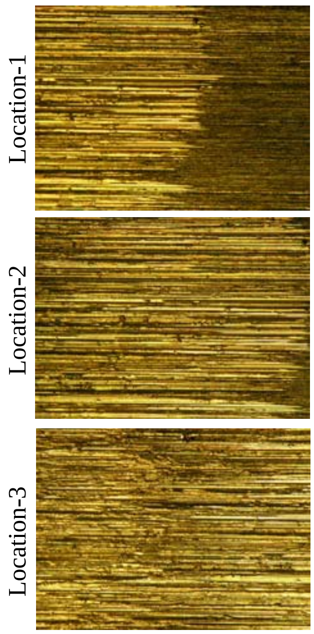


Fig.6: Micro-views of different zones of after freezing grinding at large feed and low V_w (d=80 µm, V_w=5.9 m/min)

The micro views of the transient and ground zone, shown in Fig.5 to Fig.8 visualize that;

- material removal is accomplished mainly by shearing and abrading
- increase in infeed or depth; if not very small, does not affect chip formation mode
- the parallel abraded grooves smeared and overlapped
- the ground and transient zones attained lot of plastic deformation, fine traverse surface cracks, redepositions, and grain pull out (Fig.7).
- the depth of the abraded grooves gradually decreased outward expectedly in down grinding (Fig.8)

The mode of chip formation and surface characteristics of the ground and transient surface become more evident when observed more closely at higher magnification as can be seen in the micro-views shown in the Fig.9.

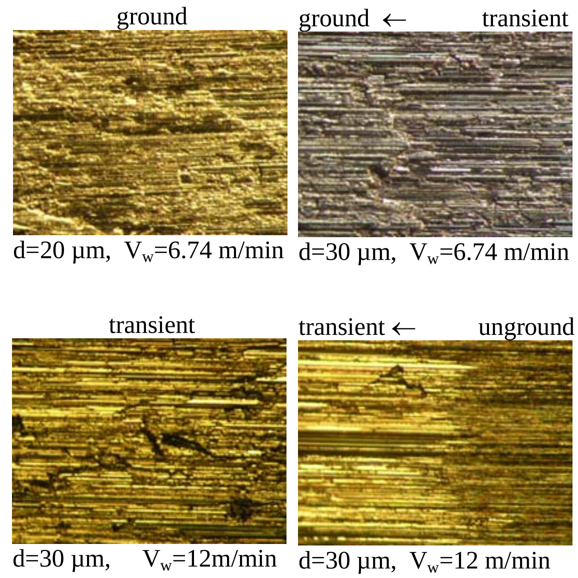


Fig.9: Detail micro-views of the surfaces after freezing grinding at different infeeds and work feeds.

5 Conclusions

1. The simple manually operated quick-stop device worked desirably well to enable study of actual mechanism of grinding.
2. The action and role of the grits become much different and complex when they actually work in cluster than under single grit action.
3. Further improvement in the quick stop device is possible and then more realistic pictures will be evident.
4. Close study of the frozen transient zones will enable observing the role of the any grinding parameter on chip formation mode, wheel-job interactions, and surface characteristics.

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